भारतीय मानक
Indian Standard

IS 14458 (Part 7) : 2022

पहाड़ी क्षेत्र के लिए प्रतिधारक भित्ति — मार्गदर्शी सिद्धांत

भाग 7 परिधीय प्रबलित गबलों की दीवारों का निर्माण

Retaining Wall for Hill Area — Guidelines

Part 7 Construction of Peripheral Reinforced Gabion Walls

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October 2022 **Price Group 5**

Hill Area Development Engineering Sectional Committee, CED 56

FOREWORD

This Indian Standard (Part 7) was adopted by the Bureau of Indian Standards after the draft finalized by the Hill Area Development Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

Retaining walls are structures, which support the backfill and maintain the difference in elevation of the two ground surfaces. They are generally located at the toe of cut slopes on the valley side of a hill road section or excavated platform. Retaining walls are effectively utilized to tackle the problems of landslides in hill areas by providing support to the hill slopes or cut slopes.

If the retaining walls are not provided at the toe of hill excavations, the gradual slope degradation may often lead to progressive slope instability and environmental degradation resulting from unprotected excavation. This standard (Part 7) is therefore formulated to provide necessary guidelines for the construction of peripheral reinforced gabion retaining walls for the protection of cut slopes in the hills. The other parts formulated in the series are:

Part 1 : 1998 Selection of type of wall
Part 2 : 1997 Design of retaining/breast walls
Part 3 : 1998 Construction of dry stone walls
Part 4 : 2018 Construction of banded dry stone masonry walls
Part 5 : 2018 Construction of cement stone masonry walls
Part 6 : 2018 Construction of gabion walls

Further parts being formulated are:

a) Construction of RCC crib walls,
b) Design of RCC cantilever walls/buttressed walls/L-type walls, and
c) Design and construction of reinforced earth retaining walls.

The choice of a particular type of retaining wall is dependent on the nature of the ground including geology, budget and availability of construction materials in the vicinity. A peripheral reinforced gabion (PRG) wall contains systematically partitioned gabion units, tied to a series of pipes along the periphery, which is grouted to the ground below. In fact, it is the same as the ordinary gabion wall that is attached to the pipes on the periphery of boulder filled containers to increase their stability, durability and efficient functioning as compared to the conventional gabion walls. To create a PRG wall, a series of boulder filled wire fabric containers are tied together along their length in a direction generally perpendicular to the overall slope direction. Since the interconnected and variable size gabions filled with boulders are anchored to the ground below along the periphery, they can be considered as fairly rigid walls, which are highly pervious in nature. In addition to serving as a retaining wall for loose slope debris and soil, they are effectively used as protection walls to prevent bank erosion, parapet walls along the road, sea walls, channel lining, revetments and other such works. They are particularly useful for the grounds, characterized by loose materials, water logged conditions and even having shallow water conditions as the pipes can be anchored to deeper levels. In future, the PRG walls shall be effectively designed for many of the infrastructures like highways, railways, bridges, river front structures, bridge abutments, culvert protection works and many other uses. This standard particularly deals with its construction as a retaining wall at the toe of cut slopes and natural slopes.

The composition of the Committee responsible for the formulation of this standard is given in Annex A

For the purpose of deciding whether a particular requirement of this standard complies with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RETAINING WALL FOR HILL AREA — GUIDELINES

PART 7 CONSTRUCTION OF PERIPHERAL REINFORCED GABION WALLS

1 SCOPE

This standard (Part 7) deals with the construction aspects of peripheral reinforced gabion (PRG) walls used for protecting cut slopes as well as natural slopes at the toe of the slope.

2 REFERENCES

The following standards contain some provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1239 : 2004	Steel tubes, tubulars and other wrought steel fittings — Specification (*sixth revision*)
2062 : 2011	Hot rolled medium and high tensile structural steel — Specification (*seventh revision*)
16013 : 2018	Welded wire gabions (metallic-coated or metallic-coated with PVC coating) — Specification (*first revision*)
16014 : 2018	Mechanically woven, double- twisted, hexagonal wire mesh gabions, revet mattresses, rock fall netting and other products for civil engineering purposes (galvanized steel wire or galvanized steel wire with polymer coating) (*first revision*)
14458 (Part 5) : 2018	Retaining wall for hill areas — Guidelines: Part 5 Construction of cement stone masonry walls

3 GENERAL

A peripheral reinforced gabion (PRG) wall contains systematically partitioned gabion units, tied to a series of pipes along the periphery, which is grouted to the ground below. In fact, it is the same as the ordinary gabion wall that is, attached to the pipes on the periphery of boulder filled containers to increase their stability, durability and efficient functioning as compared to the conventional gabion walls. To create a PRG wall, a series of boulder filled wire fabric containers are tied together along their length in a direction generally perpendicular to the overall slope direction. Since the interconnected and variable size gabions, filled with boulders are anchored to the ground below along the periphery, they can be considered as fairly rigid walls, which are highly pervious in nature. In addition to serving as a retaining wall for loose slope debris and soil, they are effectively used as protection walls to prevent bank erosion, parapet walls along the road, sea walls, channel lining, revetments and other such works. They are particularly useful for the grounds, characterized by loose materials, water logged conditions and even having shallow water conditions as the pipes can be anchored to deeper levels.

The PRG walls are quite useful in hill infrastructures as toe support for cut slopes and natural slopes. A PRG wall is basically a gravity retaining structure for retaining the soil behind by its weight and section with grouted pipes supporting them against overturning. The high porosity and permeability of gabions prevent the pore-water pressure development behind the walls, which is a major advantage here. The PRG walls also have the advantage of being able to withstand significant deformations and are moderately flexible within the units. These structures blend with the surroundings and allow vegetation to take roots through the structure which enhances the life of the structure.

The PRG walls are suitable in various field conditions, particularly where the terrains are liable to become saturated or where the foundation is composed of relatively compressible materials like debris and other unconsolidated materials. Since the peripheral ends are anchored to the ground below, they are costlier as compared to conventional gabion walls. But they provide long term stability to the wall and also can easily accommodate large deformations. Hence, they are highly useful in areas where considerable deformations are anticipated due to water charging or loose ground conditions. In view of its added stability and usefulness in variable conditions, these walls may prove to be helpful in many areas of rugged and unstable Himalayan terrains. If basic facilities like portable drilling machines and grouting are created, these types of economic and highly stable walls can effectively replace conventional gabions, particularly along road cut slopes.

4 MAIN COMPONENTS OF PRG RETAINING WALL

4.1 A PRG retaining wall is basically a gravity structure, made by stacking gabion boxes, which are filled with rock blocks and tied together among themselves as well as with the peripheral pipes. The PRG walls have four major components namely pipes along the boundary of individual rows, gabion boxes, blocks for filling gabions and backfill.

4.2 Pipes

Holes are drilled along the boundary of individual rows at required spacing and the Galvanized iron pipes and fittings as per IS 1239 are inserted in these holes. Depending upon the size of holes, pipes of different sizes ranging from 80 mm to 120 mm are used for tying the stone filled gabion box along the periphery. Below the ground level, these pipes are perforated, to facilitate effective grouting of pipes. The diameter of perforation is generally 10 mm. Two holes are provided in one row which is opposite each other, and the centre to centre distance of each row is 100 mm. The second row of perforation is provided perpendicular to the axis of the first row or perforation. The perforation is started 0.2 m to 0.3 m above the pipe end.

4.3 Gabion Box

The gabion boxes as per IS 16013 or IS 16014 are stacked between the two linear rows of pipes. The selection of the gabion box and its construction is decided as per site conditions. The most commonly used gabion boxes are rectangular fabricated double twisted steel woven wire mesh having mesh sizes ranging between 60 mm and 80 mm with heavily galvanized. The box is divided into cells by transverse diaphragms. For using the gabions in harsh and aggressive environments additional PVC coating is done over the heavily galvanized steel wire. Nylon, polypropylene and polyethylene materials may also be used in specific conditions in view of their lightweight and corrosion resistance.

Gabion boxes are designed and manufactured as per the field requirements with all components mechanically connected at the production facility. The external face and top lid are made from the same mesh. The ends, back, and diaphragm are connected to the base at the installation site by lacing wires or rings as per IS 16014 or any other methods. All perimeter edges of the mesh forming the basket have selvedge with wires having a diameter of about 1.5 times that of the wire mesh to prevent unravelling. The gabion base, top and sides should be formed from a single piece of mesh. The completely woven wire mesh box can stretch or contract in two directions in its own plane and thus a rectangular wire-mesh basket filled with rock blocks can deform in any direction. Welded wire mesh is also manufactured from steel wires electrically welded at each intersection. It does not have the ability to stretch and contract so that the baskets are less flexible as compared to woven wire-mesh gabions. Gabions are supplied to the project site from the factory with their components folded flat, collapsed and packed in bundles.

A variety of cage sizes are used taking into account the spacing between the rows and terrain considerations. However, the modules of 1.5 m to 5.0 m (parallel to the hill face) × 0.5 m to 1.0 m (height) × 0.7 m to 1.0 m (width) could be preferred depending on local conditions for PRG walls. The above type of simple box is used for walls up to 6 m height. However, if the walls are to be designed for more heights, strong boxes to withstand higher gravity loads are required. For that purpose, additional measures such as bracing wire/stiffener as well as fasteners/overlapping fasteners/steel rings can be provided in addition to other safety measures. Since low to medium height walls are extensively constructed in hills for various purposes, here focus is on PRG walls up to 6 m. If more height of the wall is required, a horizontal or inclined (up to 30^{o}) bench/platform shall be provided at 6 m height (*see* Fig. 1) having a bench width of 3 m. By this way, walls for more height can be planned safely by providing such benches.

4.4 Gabion Infill Material

Rock blocks/boulders used for filling gabions should be fresh to fairly fresh, hard, angular to sub-rounded, durable, clean and well graded. Weathered rock blocks shall not be used as they tend to break under loading. Care should be taken to ensure good quality that they do not lose their integrity on exposure to the atmosphere or water during the life of the structure. The maximum size of the rock block should not exceed two-thirds of the depth of the gabion to be filled or 300 mm, whichever is less. The generally preferred size is 150 mm to 300 mm. The smallest dimension of the rock block should be at least twice the largest dimension of the mesh aperture.

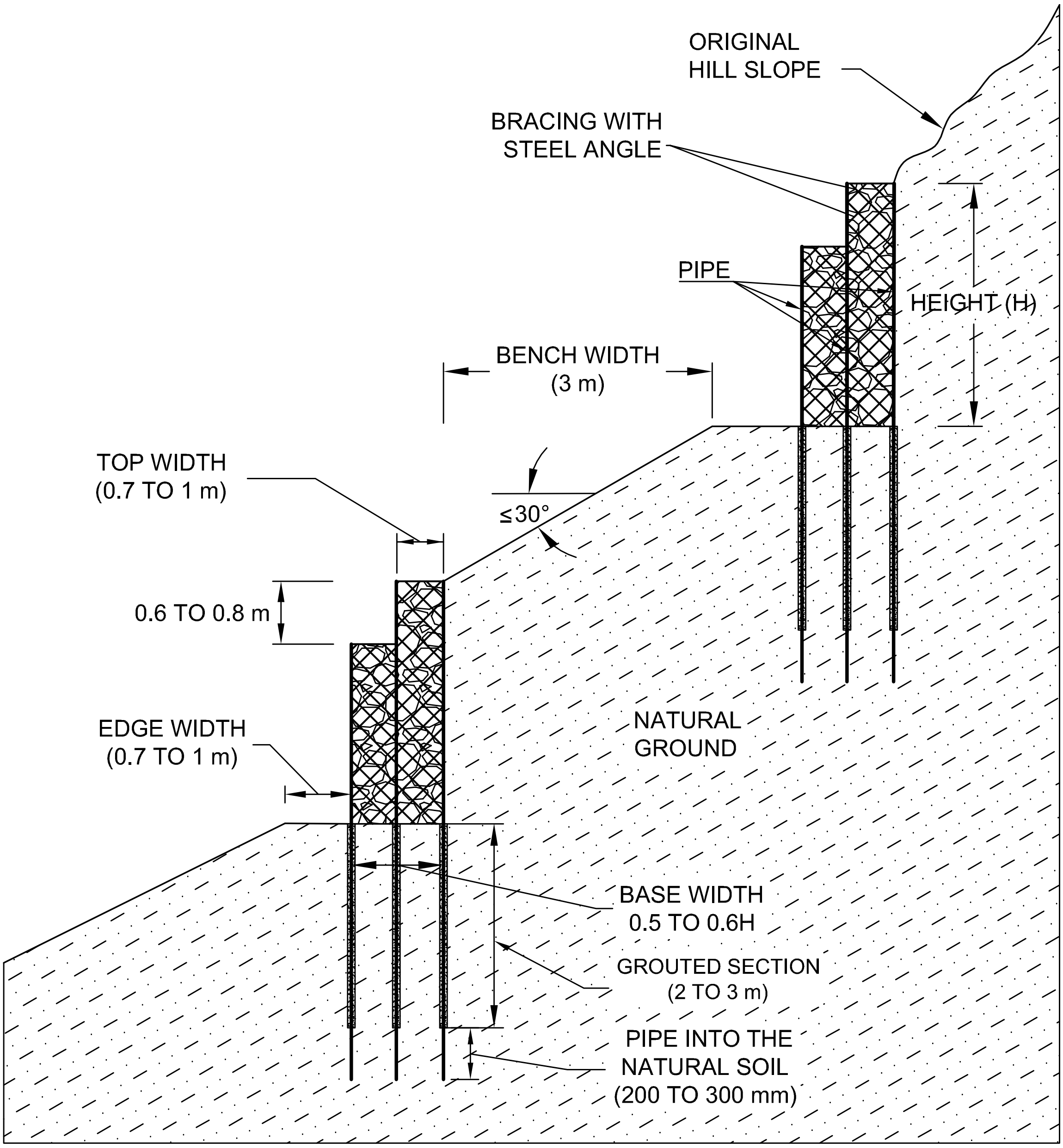

FIG. 1 TYPICAL SECTIONAL VIEW OF TWO UNITS OF PRG
(ONE UNIT OF PRG WITH TWO ROWS GABION WALL)

4.5 Backfill

The hill cutting for gabion wall construction is generally minimum particularly in case of low height walls (< 3 m). However, it may be considerable in case the height of the wall is more. If the width of the backfill is 0.7 m or more, the inverted filters as suggested **7** of IS 14458 (Part 5) is recommended as backfill. Alternately depending on the requirements, other suitable filters can also be provided. If the width of the backfill is less than 0.7 m, free draining materials ranging from small boulders to gravel shall be dumped in the gap between the wall and hill cutting. In all cases of backfill, the top 0.5 m thickness shall be filled tightly with natural soil or impervious clayey soil to prevent ingress of surface water into the backfill material. The growth of vegetation on the top soil and penetrating roots through the structure of the gabion in a short time will help to blend it with the surroundings, which enhances the life of the structure.

5 DESIGN CONSIDERATIONS

5.1 The PRG retaining walls up to 6 m in height can be considered as a gravity retaining wall, that is anchored to the ground along the periphery. Based on field experiments and preliminary analysis, the following general design considerations are found to be adequate:

a) *Top width* — 0.70 m to 1.0 m, and

b) *Base width* — 0.5 to 0.6 *H* (*H* = height of wall)

5.2 Specifications of Drilling

5.2.1 For wall heights up to 3 m:

a) Size of G.I. pipes to be grouted = 80 mm to 100 mm (perforated below ground level as per **4.2**);

b) Depth of grouted drill holes = 2.0 m to 2.5 m;

c) Size of drill holes along the periphery of gabion units = 100 mm to 120 mm; and

d) Number of rows of gabion units = 2 Nos. (with a height difference of 0.6 m to 0.8 m).

5.2.2 For wall heights >3 m and up to 6 m:

a) Size of G.I. pipes to be grouted = 100 mm to 120 mm (perforated below ground level as per **4.2**);

b) Depth of grouted drill holes = 2.0 m to 3.0 m;

c) Size of drill holes along the periphery of gabion units = 120 mm to 140 mm; and

d) Number of rows of gabion units = 3 to 4 Nos. (with a height difference of 0.6 m to 0.8 m each).

5.3 Other Consideration

The following shall apply:

a) Spacing between drill holes along individual row = 0.70 m to 0.80 m (centre to centre); and

b) Spacing between rows (width of individual gabion unit) = 0.70 m to 0.80 m (centre to centre).

5.4 Depending upon the site conditions, the engineer-in-charge shall validate the design before execution and ensure safety against overall stability or global failure.

6 CONSTRUCTION PRACTICE

6.1 Foundation Preparation

Considering appropriate cross-sections across the slope, the locations of PRG walls are selected. The foundation preparation starts with the excavation of the slope to the desired width and depth. The excavation shall be limited to the desired requirement and excess excavation shall be avoided. Loose pockets, if any, shall be excavated and filled back with suitable granular or backfill material. The place should be cleared of standing water to ensure a suitable work environment for drilling and proper placement of gabions. The entire surface should be compacted well so that the density of compacted formation should be greater than or equal to 95 percent of the modified Proctor or standard Proctor value. Later the formation shall be levelled without ruts and undulations. Depending upon the width of the wall, an edge distance of about 0.7 m to 1.0 m shall be left on the valley side.

6.2 Drilling and Tying of Peripheral Drill Holes

Initially, drilling of holes on the hill side is taken up and the holes on the valley side shall be taken up later. Drilling could be done with a portable pneumatic drilling machine or any other suitable drill machine for depths of 2 m to 3 m (Fig. 1). The size of the drill hole is always bigger than the pipe inserted in it. The size difference could be about 20 mm to 30 mm to help in effective grouting. The section of the pipe inside the ground shall be perforated as given in **4.2** to allow better grouting. The size and spacing of pipes shall be as given in **5.1**.

The total length of an individual pipe shall be the depth of pipe below the ground plus the height of the wall above the ground in that location. After completion of drilling, these holes shall be filled with grout (cement: sand) ranging from 0.8 : 0.2 to 0.7 : 0.3 with a nearly equal proportion of water. In addition, 2.5 percent sodium silicate of the total quantum shall also be added to the mixture as an additive. Then the perforated portion of pipes with a conical shoe at the bottom shall be placed inside the grout and inserted/hammered into the natural soil for about 200 mm to 300 mm (*see* Fig. 2).

The projecting pipes shall be braced in the inner side with a steel equal leg angle of size ∠ 50 mm × 50 mm × 5 mm as per IS 2062 with a clear spacing of 0.20 m to 0.30 m between the angles. Across the row of pipes, the pipes shall be braced and closed after every 5 m length, to create a box type structure of (length × width × height) 5 m × 0.70 m × 1 m size. The bracing shall be fixed through nut bolts/welding. Bracing through a nut bolt shall be preferred as the long-term performance of the nut bolt is better than the welding. Three rows of drilling are done if two rows of walls are to be constructed and four rows of drilling are done if three rows of walls are preferred. The height difference of the two gabion walls is 0.6 m to 0.8 m.

6.3 Placement of Gabion Boxes and Filling

Gabion boxes of suitable size shall be placed systematically inside the space formed by interconnected pipes through steel angles. Initially, the boxes are placed for a height of 1 m covering the desired length and the space inside shall be filled tightly with hand packed blocks/boulders as per **4.4**. These boxes are closed and tied to the pipes before placing other boxes above. In this way, the entire height is covered with blocks/boulders filled gabion boxes in parts of 5 m length (*see* **6.2**). Later, once all the lids of the boxes are closed, steel angles are welded to the pipes on the top of each segment to make a protective cover on the top (Fig. 2). It is to be noted that for making the protective cover welding is more suitably used. Similarly, the whole length of the individual row and further rows on the valley side can be covered to construct a PRG wall of desired dimensions.

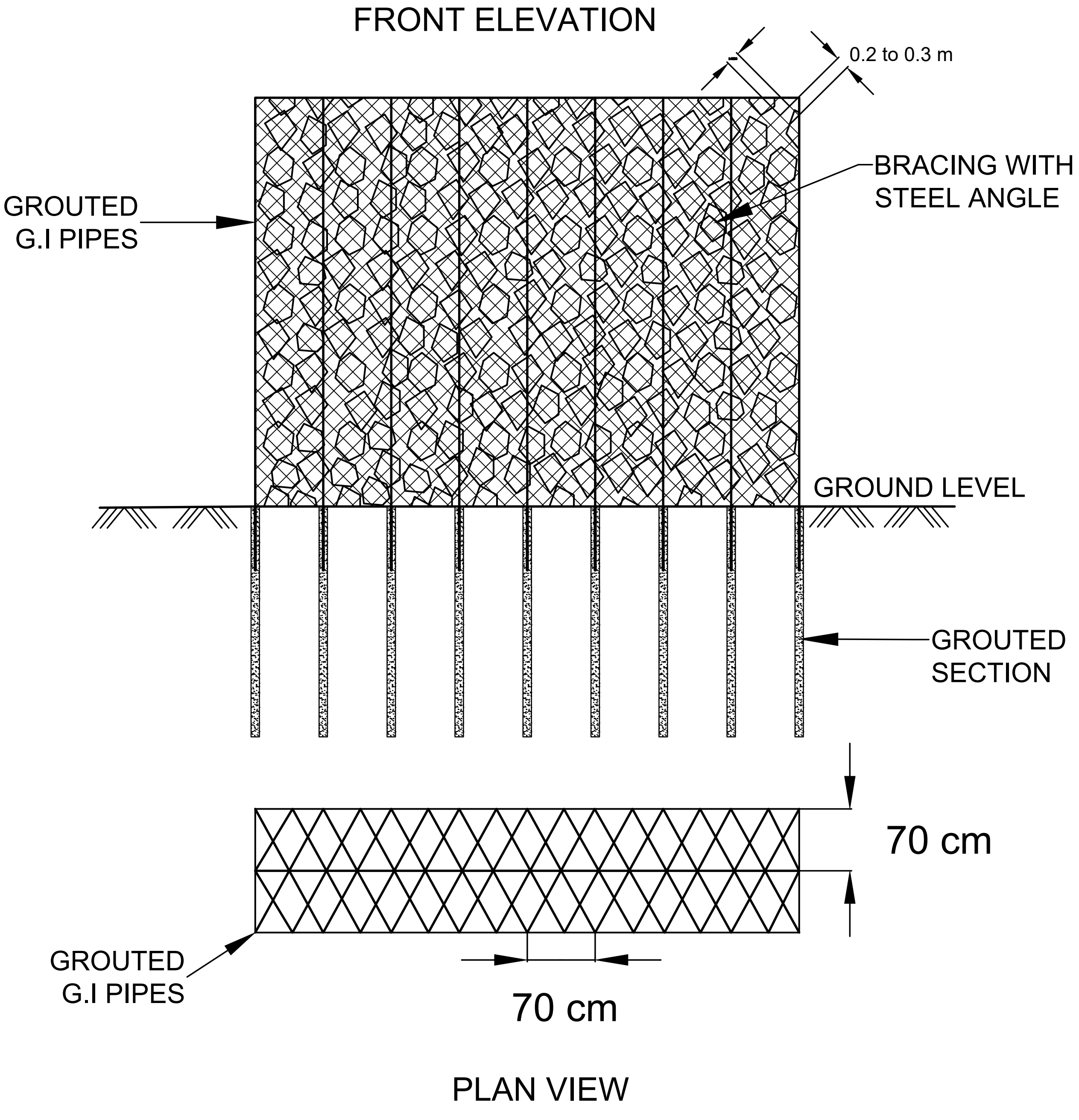

Fig. 2 Typical Details of Two Row Gabion Walls in a Single Prg Unit

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

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Organization	*Representative(s)*
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